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SmartStaff: a support concept for staff planning

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SUMMARY

A new concept has been evaluated to support decision making in teams. The concept encompasses a shared representation and interactive use of planning information in a team environment, and consists of individual workplaces, generation and representation of ideas, and shared interactive large screen displays. This so-called SmartStaff concept has been evaluated during a simulated operation by the Task Group Staff of the Royal Netherlands Navy. By means of questionnaires the staff members were asked to assess their current work environment and the potentials of SmartStaff. The results show that the concept provides better general support for group decision making. SmartStaff supported better the presentation and conveyance of ideas, facilitated time management and decreased the ambiguities of the plans presented. However, the quality of the final plan did not improve.

KEYWORDS

Team decision making, Team Planning, Group Support Systems, Task Group Staff

1 INTRODUCTION

A concept for supporting a planning task in a team has been evaluated. The goal of this so-called SmartStaff concept is to support a team in developing a common representation of both the problem space (an operational situation) and the solution space (a plan to be developed). This concept has been implemented in an environment where planners can work both individually and together, while using and producing information in a highly interactive way.

A number of researchers employ the term 'shared mental model' in explaining effective team behaviour (e.g., Orasanu, 1990, Rouse, Cannon-Bowers & Salas, 1992, Stout, 1995). The SmartStaff concept encompasses a *representation* of a shared mental model of the *operational situation*. SmartStaff also includes a *representation* of a shared mental model of the *plan* that the team is developing.

To improve our understanding of team support, our aim is not to evaluate a particular environment but rather the concept behind it. In order to evaluate the concept

empirically, we have implemented the concept in a naval command and control task of the Task Group Staff of the Royal Netherlands Navy (RNLN) that has operational command over a number of naval platforms.

Supporting naval command and control teams has been the subject of a large research program called TADMUS (Tactical Decision Making Under Stress); see Cannon-Bowers and Salas (1998) for an overview. Morisson, Kelly, Moore and Hutchins (1998) discuss a number of decision support systems developed in this program. The design of these systems were based on the naturalistic decision making theory (Zsombok and Klein, 1997), stating that a decision is most of the time based on a recognition of a previously experienced pattern. Decision support should therefore facilitate the recognition of these patterns. Example decision support systems designed by Morisson et al. are a geo-plot (a computer graphic representation of a geographic area with associated information, i.e. land masses, political boundaries, symbols for assets and units), and a track profile (graphically displaying the altitude of an air contact over time and range from own ship). However, supporting team planning has not been part of the research program.

A new conceptual approach is an important aspect of the development of a new command frigate, the platform that embarks the Task Group Staff. Traditionally, the RNLN designs its own frigates. Since the start of operation of the current command frigate, three decades ago, much has changed in the field of information and communication technology. New ways of working have to be designed, updated not only to the current state of technology but also to be prepared for developments in the future. Therefore, a conceptual evaluation is more valuable than merely a state-of-the-art based technological evaluation.

1.1 Technological Development

A most significant change in the past decades is the use of electronic information in groups. McGrath and Hollingshead (1994) give three reasons why teams should work with electronic information:

- it can improve task performance,
- it can overcome time and space constraints, and
- it enhances information retrieval and exchange.

Important recent developments in command and control are the paperless ship, the large screen displays, and various electronic support tools. Electronic support tools can be categorised in different ways. Group support systems can be distinguished on the basis of time and space constraints (DeSanctis and Gallupe, 1987, Grudin, 1997). People can work together at the same place or at different locations, and also work together synchronously or a-synchronously. A second distinction of group support systems is type of task. Computer supported cooperative work can be divided in:

- communication between co-workers;
- creating and maintaining a shared information space; and
- coordination of the various interactions between the co-workers, and between a worker and the information system.

Group systems that support communication mainly deal with groups that are distributed in space, some of which work synchronously (telephone, video conferencing), and others a-synchronously (e.g., e-mail). Desktop conferencing is an example, given by Grudin (1997), of a type of support system that creates and maintains a shared information environment in which group members can share large screen displays and different electronic tools. There are several group decision support system, for example computer conferencing tools, application sharing systems, collaborative virtual environments, audio conferencing systems, and collaborative software engineering systems (Grudin, 1997, Ter Hofte, 1998).

A rather new device that can support group work is the shared electronic whiteboard. Originally, shared whiteboards were used for groups working at different locations who need to work on a common object (e.g., a document) during video conferencing, but it has been found to be useful in face-to-face meetings too. Streitz, Geissler, Haake & Hol (1994), for example, compared three conferencing configurations. In one configuration, a group of graphical designers were provided with individual workstations. In a second configuration, an interactive whiteboard was provided. The third configuration consisted of the mixture of both. They found that designers supported by both individual workstations and an interactive whiteboard performed best, in terms of quantity and quality of ideas, amount of activity, and a shared picture of the subjects of discussion. The whiteboard that was used presented a computer screen and enabled direct interaction or interaction from behind the individual workstations. The whiteboard also allows drawing pictures with an electronic pen. It appears that this concept improves performance, because the whiteboard focuses attention on the design object as well as the design process, and facilitates the comparisons of ideas (plans); while idea generation takes place interactively at the whiteboard, other members can respond to it immediately.

1.2 Support Concept

Planning may be defined as designing a sequence of actions to be taken in order to react upon an anticipated threat with regard to a mission, where all actions are heavily interdependent and where design decisions need confirmed arguments. Team planning requires that information needed for planning as well as the plan itself is shared and that, for efficiency reasons, team members can work both collectively and individually. It is essential that the separate, diverging work of members having individual expertise is followed by convergence of ideas in the team.

Current electronic tools do not support team planning. With an electronic conference tool, for instance, a group can first generate a list of individual ideas and next come to an agreement of the best one. For staff planning, however, a tool is needed that enables staff members to develop a single plan or ideas for plan refinement in a collective and integrated way rather than enabling only individual disconnected idea generation. Further, we think that for interactive planning, it is not only important to share planning information and the plan itself; sharing information about the planning process is essential as well. Information about the planning process gives other members the possibility of reacting immediately during planning. They may contribute concurrently instead of sequentially (i.e., first developing a partial plan individually, and then discussing it within the team.)

On the basis of these ideas the SmartStaff was conceptualized, having the following characteristics. A planning staff needs:

1. Both individual and shared workspaces
2. Flow of information
3. A common focus of attention
4. Concurrent idea generation

An "idea" is used as the unit for information conveyance. An idea can take various forms: text, an object (graphical, but potentially also audio), or even a reference link to another idea. Ideas can consist of sub-ideas. A plan is typically a compound idea.

We have implemented this concept with eight individual workstations and two large interactive touch screen displays (electronic whiteboards), electronic storage, retrieval and exchange of information, and an electronic idea pad: a tool for both individual and team generation and representation of ideas. To guarantee face-to-face contact and an unlimited view of the large screen displays, the workstations were lowered and positioned in a semi-circle around the large screen displays. Figure 1 shows the layout of the experimental staff room.

As idea pad we used a commercially available software tool (SmartNotebook, from Smart Technologies Inc.), but in a specific way. In the idea pad, ideas may be put on a single page, or divided over different pages. The development of an idea may be recorded, enabling skipping back to an earlier development phase. Elements of an idea can be made from scratch or may be imported

from existing sources, including other idea pads or idea pad pages. Other available electronic information sources are the tactical situation, meteorological information, charts, mission statement, messages, intelligence, etc.

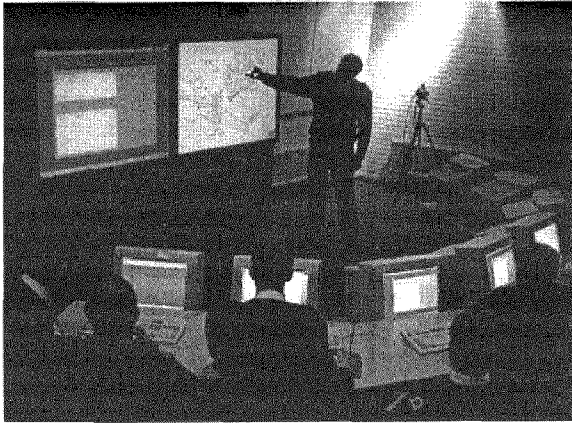


Figure 1: The layout of the experimental staff room.

Ideas can be exchanged with a specially developed tool. When a team member wants to submit an idea he can send his idea pad to a common idea repository, presented at the large screen display with the name of the sender, and a one-line description. The content of the private idea pad can be discussed within the team, and accepted (possibly after revision by the individual or the team) as (part of) a shared team idea, or thrown away. The other

way around, a shared team idea can be fetched from the common idea repository and placed on the individual's own work space, for example for extension, correction, or refinement.

1.3 Task Analysis

This paper describes the empirical evaluation of the SmartStaff concept in the naval command and control task of task group staff planning. The aim of this study is to examine whether the team decision making performance improves when the team is supported by the SmartStaff concept. More specifically, we want to investigate whether Smartstaff improves a shared picture of the situation and the plan, is more time-efficient, improves the communication of ideas and the quality of the final plan.

Before the evaluation we first analysed the work of the Staff. Naval platforms seldom operate individually, but rather in a group, called a Task Group. The Task Group Commander, supported by a team varying from five to fifteen members with a specific individual expertise, such as in meteorology, intelligence, communications, and the different warfare areas, exercises command from a dedicated frigate. Monitoring, threat assessment, and control of operations of the whole Task Group takes place in the staff room of this command frigate. Various phases of an operational situation can be distinguished, differing in threat, workload and intensity of the team decision making process. The planning process is illustrated in figure 2.

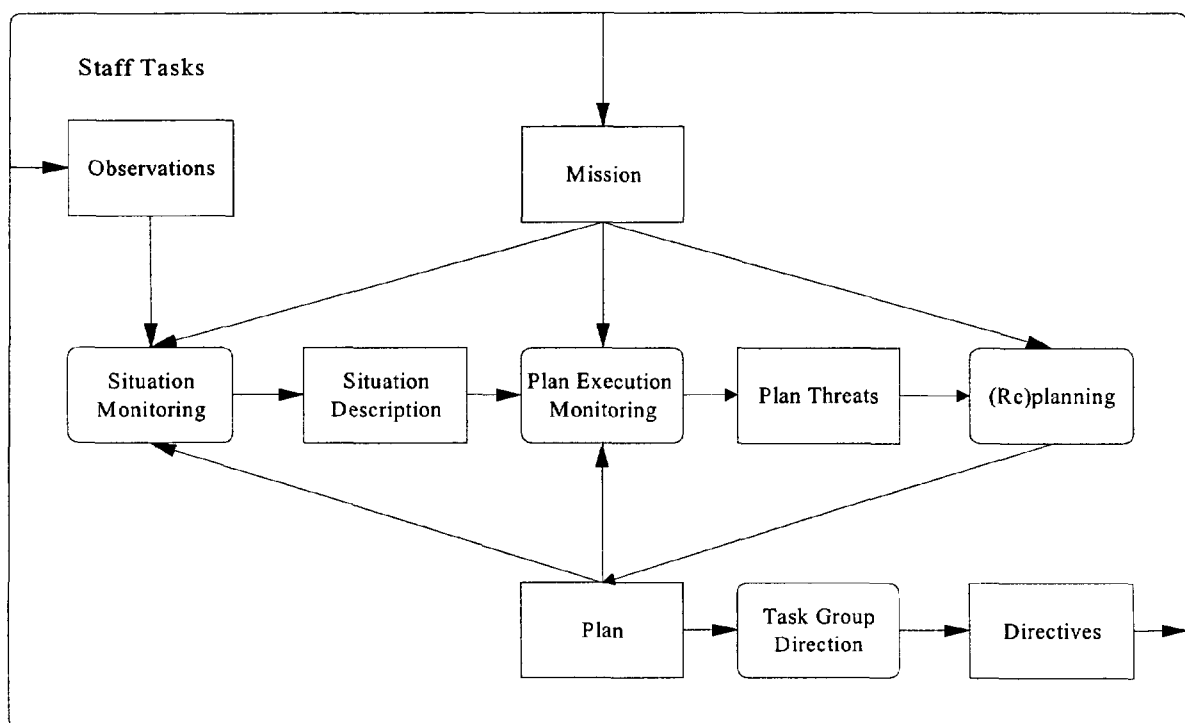


Figure 2: Staff tasks. The rounded boxes are tasks; the shaded boxes are information boxes; arrows are data dependencies

Based on its mission, the Staff plans the activities of the task group and executes the plan by directing the units. During execution, both the situation and the execution progress is monitored. When the situation changes and problems in executing the plan are anticipated, or the mission changes, the plan is revised. This process is carried out in three cycles:

1. long-term (re)planning (more than half a day in advance)
2. short-term (re)planning (up to half a day in advance)
3. near-real-time decision making

During these cycles, briefings take place regularly to inform the members of the staff. Re-planning occurs by generating collectively a solution in a rough form, and then working out the details in the plan individually, and next, discussing them collectively. The final adaptations are translated into orders and sent to the task group units.

In its current environment, the Task Group Staff does not work much with electronic information. The Staff does not have electronic presentation or electronic data exchange facilities; much is done on paper, and on white boards and tote boards.

2 METHOD

2.1 Subjects

All 14 RNLN Task Group Staff members served as subjects, 6 Petty Officers 1st class, 6 1st Lieutenants, a Captain and a Commodore. The 1st Lieutenants were experts in one or more particular areas (operations, the three warfare areas, meteorology, communication, and intelligence). The Captain and the Commodore were the team leaders. The Petty Officers supported the Officers. All subjects had significant operational experience, also within this team (except for the Captain). Mean age was 39 years (34 to 50).

2.2 Design

The RNLN Task Group Staff carried out their work during a simulated operation in the SmartStaff-based environment. For pragmatic reasons, we were not able to make a pure experimental comparison between this environment and an environment not based on SmartStaff. Only one RNLN Task Group Staff exists and its time is restricted. Therefore, the staff members were asked to compare this experimental environment with their normal working environment. To make their work as similar as possible, we used an operational scenario that was comparable with a training scenario they had used earlier in their current environment. In addition to this self assessment, we invited two experts in the field as independent observers, to collect information for the interpretations of the results.

Three questionnaires were developed: one for assessing the current environment (A), one for assessing SmartStaff (B), and one for comparing directly both environments (C). With the three questionnaires,

SmartStaff was tested in two ways:

- Indirectly, by comparing the questions about the current environment (questionnaire A) with the questions about SmartStaff (questionnaire B)
- Directly, by testing the null hypothesis that SmartStaff and the current environment supports the Task Group Staff equally well. This is done by comparing the questions in which both environments were compared (questionnaire C) with the answer 'equal'.

The subjects as well as the observers filled out the three questionnaires. The questions in each questionnaire were organised in 5 modules:

1. point of focus and shared picture (3 questions), e.g., "How often during a meeting in <the current environment> do you have a different picture of the situation than a colleague?"
2. efficient use of individual and shared time (5 questions), e.g., "How often during <the SmartStaff meeting> do you experience that you lose time?"
3. communication of ideas (5 questions), e.g., "Can you clarify your ideas with SmartStaff better than in the current environment?"
4. product quality (1 question), e.g., "How do you assess the mean quality of the plans resulting from the <current environment>?"
5. general questions (12 questions), e.g., "How well can you present your ideas to the team in <the current environment>?"; "How well does <SmartStaff> support you in participating in the team discussion?"

In questionnaire A and B, answers had to be given on a 4-point scale (bad, rather bad, rather good, good). In questionnaire C, a 5-point Likert scale was used (with answer categories 'much worse', 'worse', 'equal', 'better', 'much better'). This questionnaire also asked some open question about both environments, such as about their strengths and weaknesses, possible improvements, and the potential of SmartStaff, e.g., "Do you have any suggestion for improving SmartStaff?"

The subjects as well as the observers also took part in a group discussion, taking place after having experienced the SmartStaff environment. The group discussion was also based on qualitative questions.

2.3 Scenarios

A realistic simulation in the environment described above requires a full scenario in which the Staff directs a Task Group consisting of various frigates, tankers, an amphibious unit, air units, and a submarine, within political constraints laid down in so called Rules of Engagement. The scenario was based on a training scenario, adapted to the above mentioned three team decision making cycles.

For long-term planning, the task was to prepare a plan to escort a Task Unit to a particular waiting area prior to an amphibious landing by NATO forces, and to execute the plan within 76 hours. For short-term planning the task was to formulate a group assessment of the present

tactical situation, including a tentative identification of surface contacts, and to (re)task available assets and units in order to accomplish the task. For near-real-time decision making, the Staff had to assess the development of the tactical situation, to reconsider eventually the identity of the surface contacts, and to decide on manoeuvring the formation or to engage. Information needed for planning and decision making, such as mission, rules of engagement, observations, meteorology, intelligence, possible threats, etc., was made available electronically.

2.4 Procedure

One week in advance, the information used in the scenario, consisting of 30 pages of text, sea charts, etc., was provided to the Task Group Staff. Data collection took place in one afternoon, from 12 to 6 pm. After a short explanation of the aim of the study, the subjects filled out questionnaire A. After lunch, the SmartStaff concept was introduced and explained. Next, the subject were trained for one hour in using the support tools, working through a number of exercises about forming and presenting ideas, and sending and fetching them. The game started at 2.30 and lasted for two hours. In the first hour of the game, long-term planning took place, without the Task Group Commander (TGC). The plan was subsequently briefed to the TGC. In the remaining time, short-term planning and near-real-time decision making was carried out, as a reaction to a developing threat. In these tasks, the TGC participated fully. After a break, questionnaires B and C were filled in. The session concluded with the group discussion.

2.5 Results

The results came from the three questionnaires filled in by eight staff officers, the questionnaire filled in by one

observer (the second observer didn't show up), and remarks made during the group discussion. Reliability analysis showed that two items in module 2 (efficient use of individual and shared time) had low item-total correlation; these items were left out of the analysis. The reliability of the remaining questionnaires was reasonable to good (Cronbach's alpha .97 for questionnaire A; .74 for B; and .71 for C).

In table 1 the results are presented for the four specific performance criteria, derived from the first four modules from the questionnaires. A fifth overall performance assessment is added, derived from all five modules. A Wilcoxon rank test was used. Each performance criterion was tested by averaging the scores across the questions of a module. The table shows the mean scores together with their standard deviation (between brackets), and the level of significance (p-values).

The Task Group Staff assessed that the SmartStaff based environment supported their decision making better than their current environment ($p \leq 0.05$ for both comparisons). Important to remark is that the subjects regularly noted they evaluated in questionnaires B and C the potential of the SmartStaff *concept*, not the current experimental *implementation*, for which is clear that certain interaction mechanisms and the speed of data exchange can be improved.

SmartStaff was found to provide a less ambiguous shared picture shared of the situation and the plan, when the two environment were compared directly ($p < 0.05$). No significant difference was found for the absolute assessments of the two environments.

The Staff also had the opinion that with SmartStaff their time was used more efficiently. Again, this result was only found in the direct comparison ($p < 0.5$). A drawback, put forward by some subjects, was that carrying out individual work in the SmartStaff environment may distract one from shared decision making.

| Performance criterion | Mean Score (Standard deviation) | | | p-values of difference | |
|--|---------------------------------|---------------|---------------|------------------------|-----------|
| | A Cr.α=.79 | B Cr.α=.74 | C Cr.α=.71 | A-B | C-'equal' |
| overall performance (module 1 to 5; 24 questions) | 2.81 (0.32) | 3.01 (0.30) | 3.77 (0.25) | .05 | .01 |
| shared situation picture (module 1; 3 questions) | 2.95 (0.49) | 3.29 (0.42) | 3.49 (0.32) | n.s. | .02 |
| time efficiency (module 2; 3 questions) | 2.96 (0.49) | 2.92 (0.43) | 3.65 (0.49) | n.s. | .02 |
| idea communication (module 3; 5 question) | 2.66 (0.32) | 3.08 (0.55) | 4.22 (0.41) | .06 | .01 |
| product quality (module 4; 1 question) | 3.25 (0.46) | 3.13 (0.35) | 3.33 (0.41) | n.s. | n.s. |

Cr.α: Cronbach's alpha; n.s.: not significant;

A: Current environment; values ranging from 1-4 (bad, rather bad, rather good, good);

B: SmartStaff environment; values ranging from 1-4 (bad, rather bad, rather good, good);

C: Direct comparison; values ranging from 1-5 (much worse, worse, equal, better, much better).

Table 1: Overview of the results

With SmartStaff, the quality of ideas generated is not better compared to their current environment ($p=0.35$ for comparison afterwards, and $p=0.11$ for direct comparison).

The Task Group Staff was clear about the value of SmartStaff for the communication of ideas. The subjects unanimously thought that the SmartStaff based environment is better or much better in this respect compared to the current environment. ($p=0.06$ when indirectly compared; 0.01 for direct comparison). Also, in their comments the subjects expressed the strength of SmartStaff on this aspect.

The assessment of the observer was in accordance with the assessment of the Task Group Staff.

4 GENERAL DISCUSSION AND CONCLUSIONS

4.1 The results

The results have shown, that the SmartStaff concept has a large potential to support the planning in teams. In several respects, a SmartStaff based environment provides better support for team decision making than traditional environments:

- the shared picture of the situation and plan that staff members have is better and less ambiguous,
- time is managed more efficiently,
- presenting and communicating ideas and plans runs much better,
- general support to team decision making is better.

In one respect, SmartStaff did not have any effect: the quality of the ideas and plans were not influenced.

The latter result seems to be in contrast with the findings of Streitz and colleagues (Streitz, Geissler, Haake and Hol, 1994, Streitz, Rexroth, P. and Holmer, 1997). They found an improved output in terms of both quality and quantity when a group designed a logo together while supported by individual workstations and shared interactive large screen displays. In that task, however, the members of the team all had the same expertise and did not work together on a single logo; they generated a number of them and then selected the best one. So, the type of task and the homogeneity of the staff and the logo designers are different and a comparison can not be made easily.

It would be interesting to find out why the quality of the final plan did not improve. One explanation may be that in a planning task, in contrast to real-time decision making, sufficient time is available to make the plan better. A difference in output would only be found when there are time constraints. In such a situation, more efficient time management will play a critical role.

Individual comments of the subjects and remarks during the group discussion pointed out a number of additional aspects. The advantage of interactive large screen displays to support idea presentation and communication was particularly clear for long-term planning and for briefing. A better and less ambiguous shared picture was also found for short-term planning and near-real-time decision making. Another positively

assessed aspect was the possibility of reviewing the course of the decision making process. Time management was found to be more efficient: the subjects found it easy to change from individual tasks to collective tasks. It was recognised, however, that individual tasks that demand much concentration, could better be carried out in isolation.

4.2 Limitations of the method

Firm conclusions are limited by the method used.

One methodological problem may be the Hawthorne effect: is the effect not just a result of running an innovative system? This may be avoided by asking the staff to work in new environment for some time and measure again. Unfortunately, this is practically unfeasible. The results show, however, that the subjects were not positive on one particular aspect: quality and quantity of the ideas did not improve. Also, during the group discussion, it became clear that there was at least some reluctance to accept the new technology. These two observations may indicate that the subjects may not have been influenced by the Hawthorne effect.

Using a real team instead of artificial teams has the advantage of ecological validity. We have studied a team in its real working environment, with members having specific individual knowledge, experience, and skills who are used to working with each other. A drawback is the practical consequences. It is difficult to carry out tests on a Task Group Staff since there is only one such team in the RNLN. Still, the impact of their decision making process is enormous, so research is important, even within these methodological constraints.

4.3 Conclusions

Our aim was not to fine tuning a particular implementation but to carry out a conceptual evaluation in an early phase in a systems engineering life cycle. Such an evaluation yields the functional requirements of a system (see e.g. Sage, 1992). Neerincx, Van Doorne and Ruijsendaal (1999) show also that support systems can indeed be evaluated in an early phase. They distinguish a task level and a communication level evaluation, the former can be carried out far before the system is operational. The lessons of a conceptual evaluation are independent of the state of technology, and therefore last longer. Moreover, it helps us to understand how teams work and how they should be supported.

The present findings raise a lot of questions. Further work will address why the final product of the staff did not apparently improve. We would like to know whether this depends on group characteristics (a heterogeneous team used to work together) or type of task (no time constraints). A second question, following from the first one, is whether other types of teams may profit from SmartStaff also. Does a management board experience the same level of support? A third question is how team planning and refinement is carried out at a cognitive

level. For complex tasks, a human being has a number of mechanisms available for problem solving simplification, such as satisficing (Simon, 1978). Satisficing is a problem solving strategy often used by designers: they are satisfied with a solution to their problem when it satisfies the constraints, without further searching for a better solution. It may be the case that the product of planning and refinement can only improve when the planning problem or the problem solving strategy is more complex. If so, team planning needs specific cognitive support to manage the complexity.

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